

DOCUMENT RESUME

ED 474 124

RC 023 786

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TITLE Mathematics Education in Rural Communities: A Mathematician's View. Working Paper Series.
INSTITUTION Ohio Univ., Athens. Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics.
SPONS AGENCY National Science Foundation, Arlington, VA.
REPORT NO WP-12
PUB DATE 2003-03-00
NOTE 19p.; Paper presented at the ACCLAIM Research Symposium (McArthur, OH, November 3-6, 2002).
CONTRACT NSF-0119679
AVAILABLE FROM For full text: http://kant.citl.ohiou.edu/ACCLAIM/rc/rc_sub/pub/3_wp/Mahoney12.pdf.
PUB TYPE Opinion Papers (120) -- Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS *College School Cooperation; *Educational Change; Educational Cooperation; Educational Needs; Higher Education; Knowledge Base for Teaching; Mathematicians; *Mathematics Education; *Mathematics Teachers; Place Based Education; Professional Development; Relevance (Education); *Rural Education; State Standards; Teacher Attitudes; *Teacher Education
IDENTIFIERS Curriculum Alignment

ABSTRACT

Elizabeth City State University (ECSU) serves the 21 counties of rural northeastern North Carolina. In Fall 2000 ECSU administrators met with educators in area school districts to discuss their professional development needs. This paper reports on those expressed needs relevant to mathematics education and discusses ways to help achieve excellence in rural mathematics education. Among the challenges identified were (1) implementing state standards, aligning curricular materials with standards, and aligning preservice and inservice teacher education with the standards and school curricula; (2) connecting mathematics education to students' everyday lives by basing curriculum in local resources, environment, and events; and (3) desire of teachers to increase their mathematics content knowledge and improve their mathematics teaching skills. Mathematicians and mathematics educators can work together to ensure that university programs address mathematics teachers' needs and to develop resource materials. ECSU has increased the exposure of preservice teachers to mathematics courses to deepen teachers' understanding of the mathematics they will teach. In addition, ECSU professors are developing interdisciplinary modules for preservice teachers focused on analysis of research data collected in the nearby Great Dismal Swamp. Other strategies include involvement of mathematicians in mentoring or coaching programs for teachers, college-school collaboration to provide opportunities to discuss research and best practices in mathematics education, and development of university-school-community college partnerships to maximize resources for rural community schooling. (Contains 29 references.) (SV)

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Appalachian Collaborative Center for Learning, Assessment
and Instruction in Mathematics

Working Paper Series

Mathematics Education in Rural Communities: A Mathematician's View

Working Paper No. 12

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March 2003

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Funded by the National Science Foundation as a Center for Learning and Teaching, ACCLAIM is a partnership of the University of Tennessee (Knoxville), University of Kentucky (Lexington), Kentucky Science and Technology Corporation (Lexington), Marshall University (Huntington, WV), University of Louisville, and Ohio University (Athens, OH).



This material is based upon the work supported by the National Science Foundation Under Grant No. 0119679. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.



Mathematics Education in Rural Communities: A Mathematician's View

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**Paper presented at the
ACCLAIM Research Symposium
Ravenwood Castle, McArthur, Ohio**

November 3-6, 2002

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Carolyn R. Mahoney

Introduction

Northeastern North Carolina encompasses a twenty-one county area bordered by Virginia to the north and the Atlantic Ocean to the east. At present, this beautiful and historic region is generally isolated from the rest of the state. More than one-fourth of the region is covered by water, and the extensive wetlands and unabridged rivers and sounds interrupt land travel to and in the area. The economy traditionally has been agrarian, relying heavily on peanut, cotton, and soybean crops, along with fishing and river commerce. Farms, river estuaries, and small crossroads communities are typical. The area boomed in the 1700s, was relatively untouched by the physical destruction of the Civil War, largely ignored during Reconstruction, and in the last seventy years, consistently passed over by rail, air and telecommunications providers. Encouraged by public and private initiatives to develop infrastructure, industry, and tourism, the area currently is enjoying a gentle resurgence in growth and economic development.

I came to North Carolina in Fall 2000 as the Founding Dean of the School of Mathematics, Science and Technology at Elizabeth City State University (ECSU). ECSU has been a growing coeducational, undergraduate, public state-assisted institution since its inception on March 3, 1891. A constituent institution of the University of North Carolina multi-campus system since 1972, ECSU currently enrolls approximately 2,150 students, typically including 75% African Americans and 22% Caucasians. ECSU is the only public four-year higher education institution in northeastern North Carolina; the closest UNC campus is one hundred miles from Elizabeth City. Consistent with its

founding mission as a normal school, ECSU has continued to emphasize teacher preparation as one of its primary goals. In three of the past five years, ECSU has been number 2 in the UNC system in four-year graduation rate; and consistently is in the top five in the UNC system for freshman to sophomore retention rate. For the third time in four years, U.S. News and World Report has ranked ECSU third in the South as one of the "Top Public Schools Comprehensive Colleges – Bachelor's."

Challenges To Rural Mathematics Education

While I am somewhat new to ECSU and to the area, the Dean of the School of Education and Psychology is a North Carolina native who has been at ECSU since 1997. Beginning in Fall 2000, the Education Dean and I visited each district to introduce me to each Superintendent. In the weeks following these meetings we met with Curriculum Specialists, Assistant Superintendents, or both in each of the districts to discuss specific needs. In some districts this meeting was followed, in a week or so, by meetings with principals, classroom teachers, technology specialists and counselors. The purpose of these several meetings was to learn about the various districts so that we might adjust, revise, or design programs to meet their expressed needs.

Curriculum

The State of North Carolina Standard Course of Study (NCSCS), available at (www.ncpublicschools.org), is a framework of goals and objectives that outlines the content to be covered for each subject at each grade level and, as such, defines the curriculum in grades K-12. All of the teachers with whom we met are well aware of the NCSCS document; however, some teachers identified implementation as a challenge. For

example, teachers requested help with "crosswalking" (correlating) the textbook or curricular materials they use with the NCSCS. Additionally, teachers underscored the need to ensure that preservice and inservice professional development programs offered by universities are appropriately aligned with the NCSCS and the curricular materials used in the schools. Of course, this expressed need for help in interpreting state standards is not unique to rural areas.

Professional Development

Teachers identified a desire to ensure that materials and programs in the schools and at the university be connected to the everyday lives of students. During 1994-95, I served as an NSF Program Officer in the Statewide Systemic Initiative Program and was privileged to observe programs in more than a dozen states or commonwealths, including California, Kentucky, Montana, Ohio, and Puerto Rico. I was stricken by how crucially important this "connection to place" is. Northeastern North Carolina teachers want professional development opportunities based in the values and resources of the places we live – the ecology, the economy, the people, the folklore, the social structure, the history. They – we – want the Great Dismal Swamp, Hurricane Floyd, the gas pipeline project, runoff from hog farms, soybean yields, the Virginia Dare Lost Colonists, and wetlands restoration, to be the text, context, and vehicles for teaching mathematics.

The geography of the region poses challenges to gaining access to quality professional development. Historically, teachers have had to travel, sometimes up to three hours, to participate in workshops or academic classes. For the most part, teachers are eager and willing to improve their knowledge and skills, but they would prefer programs and classes offered at a site closer to where they live and work.

Teacher Workforce

I learned that in this rural area, students and teachers live and work in some of the most impoverished school districts in the State of North Carolina. For example, in a US Census Bureau ranking of the 100 North Carolina counties according to median household income, six of the nine selected counties rank above 80. (Selected counties are the nine counties that send the largest number of students to ECSU, in a ranking of the 21 counties in the ECSU service area). Additionally, while the state average percent of children living below poverty is 18.6, seven of the nine selected counties have more than a quarter of their children living in poverty (<http://quickfacts.census.gov>).

The economy of the region poses serious challenges to teacher retention. According to the *Teacher Turnover* Report compiled annually by the State Board of Education, the 117 school systems in the state reported that 12,610 teachers of the 90,007 teachers employed during the 2000-01 school year left their systems, for a statewide turnover rate of 13.96%. The teacher turnover rate is above the state average in six of the nine counties, and above 15% in the three counties with more than 30% of the children living in poverty. Teacher shortages are not declining; in fact, it is projected that North Carolina must find more than 80,000 new teachers by 2010. Expected retirements and enrollment increases, together with the teacher turnover challenges discussed above, point to a need for special efforts to recruit, educate, induct and retain highly qualified mathematics teachers.

Mathematics Contentt

In every school in every district we visited, teachers and curriculum specialists spoke about the need for better understanding of the mathematics that is taught in the

schools. Assistant principals and curriculum specialists, new and veteran teachers, lateral entry and national board-certified teachers, elementary, middle and high school teachers, all desired workshops and resources aimed at increasing their mathematics content knowledge as well as their ability to teach the content well. Teachers desired help with incorporating technology to improve learning; some wanted assistance with integrating content across subject areas. Teachers expressed a desire to have a readily available resource that delved deeper into a specific topic they were covering. They cited a desire for professional development opportunities (preservice or inservice) that helped the teacher see the full spectrum of mathematics taught in schools, a vertical in-depth view of what is covered in which grade. Some cited a need for assistance with making connections within the various mathematics subject areas, as well as connections or applications of mathematics to other school subjects and to "out of school" situations. Through this rich series of discussions, we learned that teachers really do want to acquire a "deeper understanding of school mathematics" (Ma, 1999).

Addressing Identified Challenges

I served on the Steering Committee of "The Mathematics Education of Teachers Project" that produced the 2001 CBMS publication *The Mathematical Education of Teachers* (Conference Board of the Mathematical Sciences, 2001), and, not surprisingly, subscribe wholeheartedly to the views expressed therein:

The Mathematical knowledge needed for teaching is quite different from that required by students pursuing other mathematics-related professions. Prospective teachers need a solid understanding of mathematics so that they can teach it as a

coherent, reasoned activity and communicate its elegance and power.

Mathematicians are particularly qualified to teach mathematics in the connected, sense-making way that teachers need. For maximum effectiveness, the design of this instruction requires collaboration between mathematicians and mathematics educators and close connections with classroom practice. (Chapter 2, Recommendation 1).

With the above statement as a philosophical underpinning, and based on my experiences and reflections, I have space to discuss five ways to help achieve excellence in mathematics education in rural areas.

Teacher Education (Elementary)

Mathematicians and mathematics educators can work together to ensure that university courses and programs address the identified needs of prospective teachers. Mathematicians also can become involved in professional development for practicing teachers, and can collaborate with mathematics educators to develop resource materials. The preceding remarks could apply to faculty at any college or university anywhere. In my opinion, the broad applicability of the statement makes it all the more compelling. One area for collaboration is improving the mathematics required of elementary school teachers. According to the *2000 CBMS Survey: Statistical Abstracts of Undergraduate Programs in the Mathematical Sciences in the United States*, 17% of four-year colleges and universities require one mathematics course for early grades certification, while 45% require two courses, 14% require three courses, 11% require four courses, and 6% require five or more courses. The *MET* recommendation is that "prospective elementary grade

teachers should be required to take at least nine semester-hours on fundamental ideas of elementary school mathematics." My own experience is illustrative. Prior to 2000, ECSU, consistent with system-wide UNC policy, required prospective elementary teachers to take one 03 unit mathematics course, College Algebra. College Algebra was a general education course taught in a traditional manner (lecture), and did not discuss particular applications relevant to teaching elementary school students. While calculator usage was strongly recommended, the course did not incorporate the use of manipulatives, and did not take advantage of mathematical software. The course provided good coverage of the algebra topics prospective elementary teachers need; however, prospective teachers received limited (if any) exposure to number theory, geometry, measurement, data analysis or probability topics. Hence, they didn't have the opportunity to develop a deep understanding of the mathematics they will teach. With support from an NSF-funded American Association of State Colleges and Universities project (<http://www.aascu.org/programs/nsf/default.htm>), we revised the requirements for prospective elementary teachers to include three semesters (09 units) of mathematics that addresses content and pedagogical content knowledge as described by Shulman (1987), Ma (1999), and Lampert (2001). The sequence takes advantage of commercial textbooks written for prospective teachers, incorporates manipulatives (base ten blocks, tile spacers, spinners, etc.) and technology (graphing calculators, Geometer's Sketchpad software, data analysis and spreadsheet software), and will help teachers develop a thorough mastery of the mathematics in several grades beyond the grade level they expect to teach as well as the mathematics in earlier grades. In particular, the courses cover numbers and operations, algebra, geometry, measurement, data analysis and probability, problem

solving, reasoning and proof, communication, connections, and representation. In all three courses teachers will discuss NCTM and North Carolina mathematics standards and how the mathematics topics they are studying are related to the standards, as well as how to "crosswalk" the standards onto the school curriculum and textbooks. As it turns out, the "crosswalking" activity has several value-added benefits. *Inter alia*, through this content analysis activity students will: learn to read mathematics books on their own; increase their understanding of the standards while increasing awareness of the various ways a single standard can be addressed; gain a better understanding of the difference between a university textbook and a school text; and increase their knowledge of what topic is taught at what grade level and how it is covered. Additionally, the Mathematics of the Dismal Swamp Project is a NASA sponsored effort that supports a team of professors from ECSU to use research on The Great Dismal Swamp (a protected wetlands area in Virginia and North Carolina) as a platform to develop interdisciplinary course modules focused on data analysis. Modules from this course are used in preservice and inservice teacher preparation, including the three-course sequence described above. Accomplishing these changes in the mathematics required of elementary teachers was not an easy task. Initially, and for a variety of reasons, few mathematics or education faculty were enthusiastic about changing. Fortunately, the AASCU project was well designed to educate administrators and key faculty to the underlying rationale for and critical importance of the proposed revisions, by bringing a team, led by the campus chief academic officer, together with other such teams from around the country to learn about and discuss recommended improvements. This project worked extremely well for our campus, and as a result, the 09-unit requirement moved through the campus approval

process rather expeditiously, after much hard work in revising the education curriculum to accommodate 06 new units.

Teacher Education (Secondary)

Most certainly, mathematicians can be involved in reviewing and revising the mathematics major or program for prospective high school teachers. Many mathematics departments have requirements aligned with the first part of the *MET* recommendation that prospective high school teachers "should complete the equivalent of an undergraduate major in mathematics." My impression, however, is that not many (as yet) are aligned with the second part of the recommendation to require "a six-hour capstone course connecting their college mathematics courses with high school mathematics."

There are challenges to implementing this recommendation, especially in small departments in rural areas. In many such departments, the mathematics major must serve the needs of all interested students, and given the relatively small number of majors, it is difficult to justify and staff a capstone course for what is perceived to be a special population of students. On the other hand, small departments frequently have the flexibility to experiment, adapt and implement improvements relatively efficiently and effectively. Departments should discuss this recommendation in departmental meetings and at conferences and workshops.

There is an emerging national dialogue about what some are calling a new field of mathematics, often referred to as "teachers mathematics," devoted to developing a profound understanding of secondary mathematics. My own voice in this conversation comes through experience on the Advisory Board of the Stuart Foundation-funded project that created the textbook *Mathematics For High School Teachers: An Advanced*

Perspective (Stanley, D., Usiskin, Z., Marchisotto E. and Peressini, A. L., to appear), and through experience with the Texas workshop developed by Callahan and Stanley, "In-Depth Secondary Mathematics" (www.tenet.edu/teks/math/resources/univforum.html). The course was designed to be used in an upper division or graduate mathematics content course for future high school mathematics teachers; the workshop is intended as professional development for practicing high school teachers. In both the course and the workshop, teachers gain a mathematically sophisticated perspective on the very mathematics high school students are learning through "extended analyses" of problems or concepts found in high school mathematics textbooks. Extended analysis (Stanley, R., 2001), starts with a solution of a problem and proceeds by opening up further mathematical possibilities that the problem presents by solving the problem in several ways, generalizing the solution, extending the solution to related contexts, and connecting the mathematics of the problem to other kinds of mathematics. The benefit of carrying out extended analysis is that it opens up these ordinary problems in surprising ways, revealing interesting and useful mathematical ideas and results that were probably not apparent even to those who have taught these very problems. ECSU is planning to adapt this course and text for use as a senior level capstone course for preservice teachers, as well as in a mathematics master's program enrolling prospective and practicing teachers.

Mentoring

Mathematicians and mathematics educators can team to provide mentor/coach programs for teachers. Mentors can discuss specific academic content and how to teach for understanding. This service is critically important in districts where there is frequent teacher turnover, and in counties that employ a large number of new, lateral entry or

provisionally licensed teachers. Mentors can be available to observe classes (live or via videotape), to model lessons in the teacher's classroom, and to participate in professional development activities. In coordination with mathematics educators, mathematics faculty can coordinate with school and district curriculum specialists to assist teachers in lesson planning and pacing, alignment of curriculum with NCSCS, and management of instructional time. As recommended by Lezotte and Bancroft (1985), mentors can help teachers learn how to interpret and use test data to plan more effective instruction and how to communicate effectively with parents concerning student progress.

Research. It is important to ensure that valuable insights and information about what takes place in school classrooms, information on state curriculum guidelines and research studies about teachers' mathematical knowledge, as well as new mathematical developments affecting what needs to be taught in the schools, appropriately inform and influence the curriculum and classroom. To facilitate a shared vision of desired educational practice, and to encourage a coherence and alignment of improvement goals, universities and schools can collaborate to create opportunities for administrators, teachers, and university discipline and education faculty to discuss research and best practices in mathematics education. In rural areas, the group likely will particularly be interested in research on adaptation of "best practices" to rural areas, and the efficacy of place-based instruction.

Since it is well documented that there is a paucity of research focused on mathematics in rural contexts, faculty can collaborate on research projects. For example, ECSU faculty will investigate the effectiveness of the revisions in the requirements for prospective elementary teachers. Faculty will conduct studies to assess how well the

Stuart course transfers to ECSU, and investigate what adaptations might be necessary for the IDMS workshop to be successful on this campus. These findings not only will inform the work here at ECSU, but also will contribute to a growing body of relevant research.

Partnerships

In rural areas, it is especially important to cooperate and form partnerships with other organizations devoted to upgrading the quality of mathematics education. For example, in North Carolina, each Community College has a well-defined footprint of counties it serves. Three community colleges serve the districts in the ECSU service area. ECSU is partnering with them to offer programs leading to the Bachelor of Science in Education, and mathematics faculty have been involved in program planning and implementation at all stages. Through this collaboration, classroom teacher assistants will be supported to complete all ECSU degree requirements for the major in elementary education, on-site at one of the community colleges. While the impetus and partial funding for establishing the program came from a statewide focus on teacher assistants, the program is open to all interested persons; hence, prospective elementary teachers can complete their preparation without having to drive great distances. This consideration is important from another perspective as well. In rural communities, counties have very different and distinct cultures and conventions. Placing a program in the community, and staffing the program with faculty who are from or knowledgeable about the community, serves to create a more favorable environment for rural community schooling and for more active community participation in schooling.

In a region noted for its persistent poverty and isolation from opportunities, university-school-community partnerships can focus on efforts to provide high quality

education with limited resources, while seeking to maximize the resources available.

Since the sustainability, growth and improvement of rural schools and communities are inextricably linked, cooperative efforts can significantly enhance the simultaneous improvement of both schools and communities.

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